(REFEREED RESEARCH)

THE EFFECTS OF FABRIC DENSITY AND NOZZLE TYPE ON STRUCTURAL PROPERTIES, DIMENSIONAL STABILITY AND SPIRALITY OF SINGLE JERSEY KNITTED FABRICS

DÜZE TİPİ VE SIKLIK DEĞİŞİMİNİN SÜPREM ÖRGÜ KUMAŞLARDA MAY DÖNMESİ VE BOYUTSAL STABİLİTE ÜZERİNDEKİ ETKİSİ

Ebru ÇORUH[1], Nihat ÇELİK[2]

[1]Gaziantep University, Department of Textile Engineering, Gaziantep, Turkey
[2]Çukurova University, Department of Textile Engineering, Adana, Turkey

Received: 21.08.2013 Accepted: 11.02.2014

ABSTRACT

Single jersey knitted fabrics are widely used in production of summer clothing and dimensional distortion caused by domestic laundery is an important issue for this type of fabrics. In this study, the effects of fabric density and nozzle type on structural properties, dimensional stability and spirality of single jersey knitted fabrics were investigated for both grey and dyed state. Fabrics were produced with 100% cotton, Ne 30/1 rotor spun yarn. Five different ceramic nozzle types were used in yarn production. The yarns were converted to single jersey knitted fabrics adjusting the yarn loop length between 14-17 cm on the machine as they were the minimun and maximum values limited by the yarn type, machine and commercially accepted conditions. The effect of nozzle type on dimensional stability and spirality is found statistically insignificant, whereas the effect of yarn loop length is significant.

Key Words: Nozzle type, Loop length, Single Jersey fabric, Dimensional stability, Spirality.

ÖZET

Süprem örgü kumaşlar yazlık giysi üretiminde yaygın olarak kullanılmakta ve bu tip kumaşlar için önemli sorunlardan biri yıkama sonrası boyut stabilitesidir. Bu çalışmada, iplik üretiminde düze tipi ve kumaş üretiminde sıklık değişiminin ham ve boyalı süprem kumaşlarda, boyutsal stabilite ve may dönmesi üzerindeki etkisi incelenmiştir. Süprem kumaşlar %100 pamuk, Ne 30/1 open-end rotor ipliğinden üretilmiştir. İplik üretiminde beş farklı seramik düze tipi kullanılmıştır. İplik ve ticari değer/kalite şartları gözetilerek 14-17 cm minimum ve maksimum değerler arasında süprem kumaş olarak örülmüştür. Sonuç olarak düze tipinin boyutsal stabilite ve may dönmesi üzerinde istatiksel açıdan önemli bir etkisinin bulunmadığı, ancak ilmek iplik uzunluğunun (sıklık değişiminin) istatiksel açıdan önemli etkiye sahip olduğu tespit edilmiştir.

Anahtar Kelimeler: Düze tipi, İlmek uzunluğu, Süprem kumaş, Boyutsal stabilite, May dönmesi.

Corresponding Author: Ebru Çoruh, ecoruh@gantep.edu.tr, Tel: +90 542 342 68 43

1. INTRODUCTION

Knitted fabric usage has been increasing all over the world due to the simple and quick production technique, lower production costs, good physical comfort and wide product range.

During the knitting process, the yarns in the fabric are constantly under stress. As a result, the fabric on the machine is more distorted than its natural relaxed state. When the fabric is removed from the machine, it has time to relax and overcome these stresses, a form of relaxation that is easily recognizable by the changes in dimensions (1).

Also, domestic laundry cause single jersey knitted fabric distortion as a result of spirality and dimensional changes. Fabrics which has this skewness have a shift towards the side seams front and back bodies. This phenomenon is still a major cause of quality problems. So many workers investigated the dimensional stability and spirality of knitted fabrics and the dependence of final dimensions on yarn spinning system, yarn number, raw material and production parameters (2-13).

Rotor spun yarn is widely used in knitted fabric production and rotor spun yarn characteristics are influenced by nozzle type with a wide range. Nevertheless, in the literature there is a lack of information about the effect of nozzle type on knitted fabrics, produced from rotor spun yarns. In this study the effect of fabric density and nozzle type on structural properties, dimensional stability and spirality of single jersey knitted fabrics were investigated for both grey and dyed state. Also results were interpreted statistically and regression equations were obtained to predict these properties before fabric production.

2. MATERIAL AND METHOD

In this study, 100% Urfa region cotton was used as raw material. Properties of cotton was tested by HVI 900 test device and evaluated on the basis of Uster statistics (14). The fabric samples were conditioned for 24 hours before testing at the standard relative humidity 65 % ± 2% and 20^0C±2^0C temperature in accordance with the standard EN ISO 139 (15). Fiber properties are given in Table 1.

Table 1. Fiber properties

Parameters	**Measured values**	**Uster classification**
Upper Half Mean Length,(mm) Mean Lenght	14,33 29,35 (mm)	Medium long
Micronaire, (µg/inch)	4,9	Medium fine
Uniformity, (%)	48,8	Very good
Strength, (g/tex) Elongation, (%)	24,83 9,9	Medium Very high
Yellow Grade (+b) Brightness Color Grade	9,47 76,60 21- 4	White cotton
Number of Contamination, (cnt/g)	551	-

During the production, five different ceramic nozzle types (K4KK plain with 4 grooves, K4KS plain with 4 grooves and aggressive flute insert, K6KF plain with 6 grooves, K8KK plain with 8 groves, KSNX spiral with soft flute insert) were used. Yarn production parameters are given in Table 2.

Table 2. Yarn production parameters

Yarn count (Ne)	30/1
Sliver number (Ne)	0,100
Number of twist (twist/m)	840
Twist factor, (α_m)	117,97
Rotor type	32 SD
Rotor diameter (mm)	32
Rotor speed (mm/min)	102.360,00
Opening roller type	OB 20
Opening roller speed (mm/min)	7.700,00
Nozzle types	K4KK,K4KS,K6KF,K8KK,KSNX

For yarn evenness, faults and hairiness, Uster Tester 4SX test device was used and the results were evaluated according to Uster statistics (16). Yarn strength was tested in accordance with the standard of EN ISO 2062. Yarn test results are give in Table 3.

In terms of the comparative value, the KSNX nozzle obtained the best yarn irregularity. *The* yarn faults measured (thin places, thick places and neps) and Uster yarn quality in terms of a comparative evaluation of the quality categories, the KSNX nozzle gave the best result. The best yarn tenacity and elongation values were obtained for the K6KF nozzle type._The best yarn hairiness value was obtained for the K6KF nozzle (17).

Table 3. Yarn test results

Parameters of the tested yarn	**Nozzle types**				
	K4KK	**K4KS**	**K6KF**	**K8KK**	**KSNX**
Uniformity (% Um)	12,67	12,72	12,79	12,75	12,29
Mass variation of coefficient (% CVm)	15,95	16,03	16,13	16,08	15,51
Thin Places (-% 50/ km)	70,3	79,5	77,3	66,3	59
Thick places (+% 50/ km)	111,8	117,5	115,3	111,3	76,8
Neps (+% 280/ km)	22,8	63,8	21,0	24,3	10,8
Strength $(kgf \times Nm)$	10,43	8,86	11,7	10,34	10,24
Breaking strength (gf)	205,3	174,5	230,4	203,6	201,7
Breaking work $(gf \times cm)$	269,5	212,3	312,3	256,5	266,5
Elongation (%)	4,86	4,47	5,04	4,74	4,96
Uster hairiness index (H)	5,16	7,12	4,99	5,30	5,34

Mayer&Cie. Relanit 3.2. type circular knitting machine with 28 fein and 32 inch diameter with positive feeding systems was used for fabric production. Knitting machine production parameters are given in Table 4.

Table 4. Knitting machine production parameters

Machine diameter, (inch)	32
Machine fineness, (fein)	28
The number of system	102
Machine speed, (rev/min)	26-28
The total number of needles on the machine	2808
Feed type	Positive
Coil position	Side

Five different fabric density values were obtained by adjusting the yarn loop length. Yarn loop length values are given in Table 5.

Table 5. Yarn loop length (50 needle)

Loop length adjusted on the machine L_A (cm)	14	14.8	15.5	16.2	17
Fabric classification according to loop length	very high density	high density	medium density	low density	very low density

Yarn loop length was determined for 50 needles in accordance with standard EN 14970 (18). Course and wale density values per cm were determined according to standard EN 14971(19). Similarly, the mean fabric weight per square-meter was determined in accordance with the standard EN 12127 (20).

The dimensional stability of grey and dyed samples were tested, using a Wascator washing tester according to the standard of EN ISO 6330 and EN ISO 5077 (21-22). The spirality was determined in accordance with standard of IWS TM 276 (23).

Dyeing recipe of sample fabrics is given in Table 6. Dyeing operation was done at HT 11 Jumbo Dyeing machine with 1 / 6 liquar ratio.

Table 6. Dyeing recipe

Dyeing recipe	Unit	Quantity
Yellow Dexf	%	0,0015
Red Dexf	%	0,018
Salt	g/l	20
Soda	g/l	15
Temperature	^{o}C	40
Color	-	pink

3. RESULTS AND DISCUSSION

The physical properties of grey and dyed fabrics are given in Table 7.

Physical properties of sample fabrics according to change in yarn loop length was found to have a significant effect. As the yarn loop length increases, number of course and fabric weight were decreased. Nozzle type did not effect the physical properties of sample fabric.

3.1. Dimensional stability

The dimensional stability of grey and dyed samples are given as the percentage of initial fabric dimensions. Figure 1 shows the dimensional change of grey and dyed samples of different nozzle types and yarn loop length (L_A). Nozzle type (NT) and loop length (L_A) was chosen as the main factor. However, grey and dyed fabrics were measured of loop length (L_M), grey fabric dimensional stability for widthwise direction and lengthwise direction (DSW_{RH} and DSL_{RH}), dyed fabric dimensional stability for widthwise direction and lengthwise direction (DSW_{RM} and DSL_{RM}), grey fabric spirality for before sanforizing and after sanforizing (QB_{RH} and QA_{RH}), dyed fabric spirality for before sanforazing and after sanforizing (QB_{RM} and QA_{RM}) were expressed.

Table 7. Physical properties of sample fabrics

Nozzle types	Fabric physical properties	Yarn loop length L_A(cm)									
		14		14.8		15.5		16.2		17	
		Grey fabric	Dyed fabric	Grey fabric	Dyed fabric	Grey fabric	Dyed fabric	Grey fabric	Dyed fabric	Grey fabric	Dyed fabric
K4KK	Loop length (cm)	14,1	14,2	14,7	14,7	15,5	15,6	16,2	16,2	17,1	17
	Course (course/cm)	19,2	18,4	17,5	16,5	16,2	15,5	15,3	14,6	14,1	13,8
	Wale (wale/cm)	12,9	14,5	12,6	14,2	12,3	13,8	12,4	13,8	12,3	13,6
	Fabric weight (g/m^2)	137,9	146,4	130,2	137,9	121,2	128,4	115,6	120,2	112,7	117,4
K4KS	Loop length (cm)	14,1	14,1	14,8	14,8	15,7	15,6	16,2	16,2	17	17,1
	Course (course/cm)	19,9	19	17,4	16,9	16,0	15,3	15,1	14,4	14,1	13,5
	Wale (wale/cm)	12,6	14,1	12,6	14,2	12,4	13,9	12,3	13,8	12,4	14
	Fabric weight (g/m^2)	137,4	145,6	128,2	137	121,1	127,9	117,5	122	112,6	119,2
K6KF	Loop length (cm)	14,1	14,2	14,8	14,7	15,6	15,6	16,3	16,2	17,1	17,1
	Course (course/cm)	19,7	18,7	18	17,0	16,2	15,8	15,3	14,6	14,2	13,7
	Wale (wale/cm)	12,7	14,2	12,6	14,3	12,7	14,2	12,5	13,8	12,6	13,5
	Fabric weight (g/m^2)	141,5	147,6	131,8	139,2	123,3	129,1	119,2	125,7	115	121,3
K8KK	Loop length (cm)	14,0	14,1	14,8	14,8	15,6	15,5	16,2	16,3	17,0	17,2
	Course (course/cm)	20,6	18,9	18,5	17,1	17,2	15,9	15,5	14,4	14,2	13,6
	Wale (wale/cm)	12,5	14,8	12,4	14,3	12,2	13,8	12,1	13,5	12,1	13,9
	Fabric weight (g/m^2)	142,2	147,3	129,7	138,7	122,8	130,7	114,7	122,3	111,2	118,6
KSNX	Loop length (cm)	14,1	14,2	14,8	14,8	15,6	15,6	16,2	16,2	17,0	17,1
	Course (course/cm)	20,1	19,1	18,3	16,9	16,3	15,6	15,4	14,5	14,1	13,8
	Wale (wale/cm)	12,4	14,4	12,5	14,2	12,4	14,1	12,5	13,9	12,5	13,6
	Fabric weight (g/m^2)	135,6	144,2	128,5	136,2	120,2	128,3	115,2	124,3	112,9	119,5

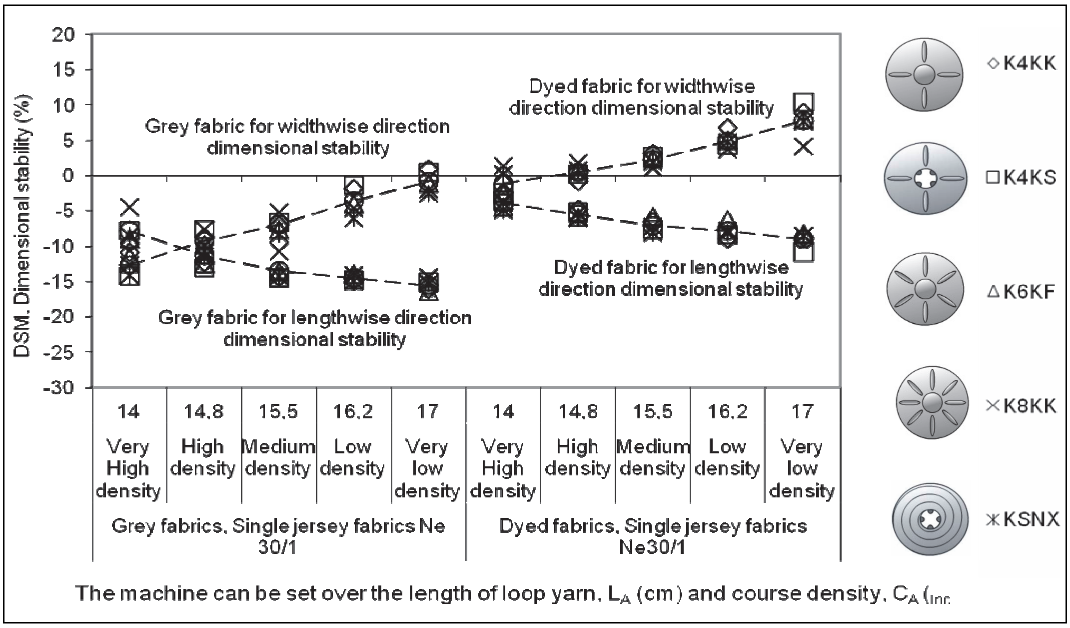

Figure 1. Dimensional stability of grey and dyed fabrics

Dimensional stability of grey and dyed fabrics are seen in Figure1. Increasing yarn loop length caused widthwise extension and lengthwise shrinkage of both grey and dyed fabrics. It was observed that there was an inverse relationship between the dimensional stability of the lengthwise direction and widthwise direction. Also, dimensional stability of dyed fabrics were better than, those of grey fabrics. This is a probable result of relaxation due to dyeing process that decrease the stresses caused by fabric production.

Regression equations were obtained for grey and dyed fabrics to estimate widthwise and lengthwise direction dimensional stability.

Widthwise direction for grey fabric; regression equation (1) was obtained from regression analysis absolute relative difference was calculated from the measured and predicted (DSW_{RH}) values by following equation (2)

$$DSW_{RH} = 3{,}9723L_A - 68{,}238 \qquad R^2 = 0{,}9975 \qquad (1)$$

$$B_{FH} = \frac{|DS_M - DSW_{RH}|}{DS_M} \times 100(\%) \qquad (2)$$

Lengthwise direction for grey fabric; regression equation (3) was obtained from regression analysis absolute relative difference was calculated from the measured and predicted (DSL_{RH}) values by following equation (4)

$$DSL_{RH} = -2{,}4502L_A + 25{,}363 \qquad R^2 = 0{,}9062 \qquad (3)$$

$$B_{FH} = \frac{|DS_M - DSL_{RH}|}{DS_M} \times 100(\%) \qquad (4)$$

absolute relative differences for different loop lengths were calculated using equations (1) and (2). According to absolute relative difference values for grey fabric widthwise direction regression equation can predict with 71,8% accuracy. Similarly, absolute relative differences for different loop lengths were calculated using equations (3) and (4). According to absolute relative difference values for dyed fabric lengthwise direction can predict with 63,9% accuracy.

Widthwise direction for dyed fabric; regression equation (5) was obtained from regression analysis absolute relative difference was calculated from the measured and predicted (DSW_{RM}) values by following equation (6)

$$DSW_{RM} = 3{,}0179L_A - 43{,}89 \qquad R^2 = 0{,}9815 \qquad (5)$$

$$B_{FM} = \frac{|DS_M - DSW_{RM}|}{DS_M} \times 100(\%) \qquad (6)$$

Lengthwise direction for dyed fabric; equation (7) was obtained from regression analysis

$$DSL_{RM} = -1{,}7113L_A + 19{,}895 \qquad R^2 = 0{,}9845 \qquad (7)$$

absolute relative difference was calculated from the measured and predicted (DSL_{RM}) values by following equation (8) absolute relative differences for different loop lengths were calculated using equations (5) and (6). According to absolute relative difference values for dyed fabric widthwise direction regression equation can predict with 85,7% accuracy. Similarly, absolute relative differences for different loop yarn lengths were calculated using equations (7) and (8). According to absolute relative difference values for dyed fabric lengthwise direction regression equation can predict with 81,7% accuracy.

$$B_{FM} = \frac{|DS_M - DSL_{RM}|}{DS_M} \times 100(\%) \qquad (8)$$

3.2. Spirality

Figure 2 shows, the spirality of grey and dyed samples of different nozzle types (NT) and yarn loop length (L_A).

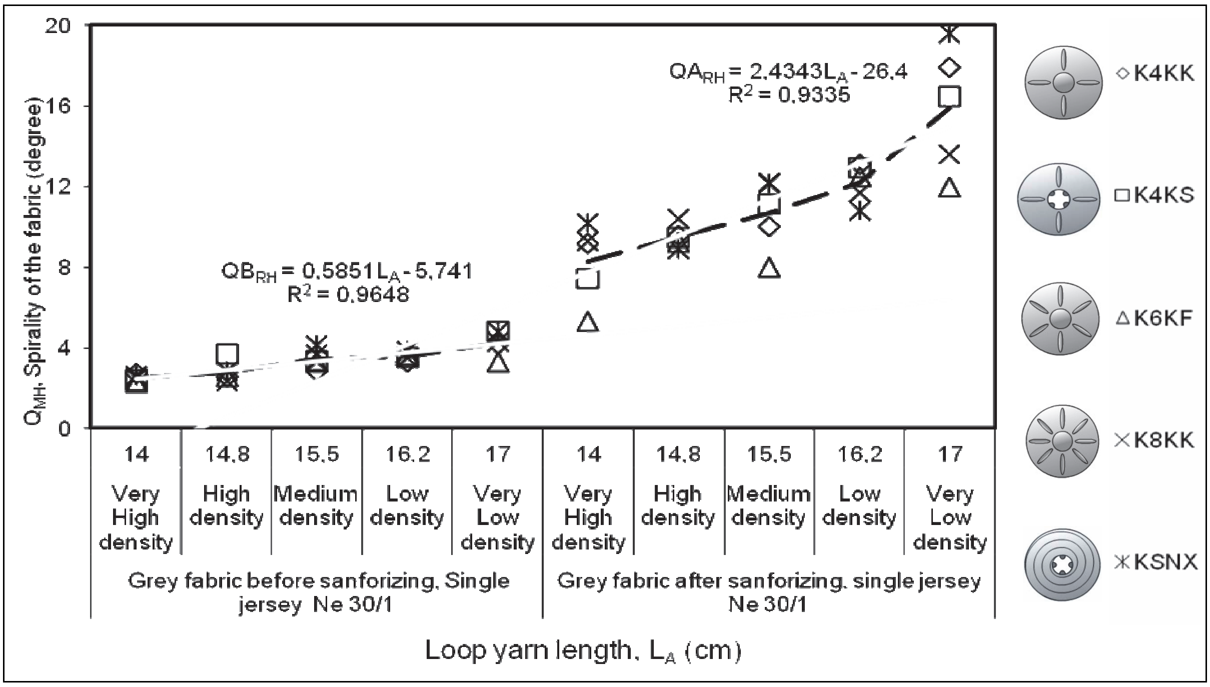

Figure 2. Spirality of grey fabric before and after sanforizing

Figure 2 and 3 shows the spirality for the grey and dyed fabrics measured before and after the sanforizing process. Regression equations fitted for the data are also given with the figure. It was clearly seen that the fabric course density and loop length have an important role for spirality behaviour of single jersey knitted fabrics. In general, the spirality decreases with the increase of the fabric weight. Similar results were seen in previous studies (4,5,8,10,12). Increasing loop length causes the loops to have higher dimensions and increased loop mobility. So these loops become more prone to shape distortion which cause higher spirality. In addition, sanforizing process caused higher spirality of the fabric samples used in this study. However the above comments of this study are only given to explain the connections between spirality and before and after sanforizing process. It has to be related to not only the yarn loop length and its shape mainly but also many of the other factors such as the dimensional changes, yarn characteristics, dyeing process etc.

For grey fabric before sanforizing; regression equation (9) was obtained from regression analysis

$$QB_{RH} = 0,5851L_A - 5,741 \qquad R^2 = 0,9648 \qquad (9)$$

absolute relative difference was calculated from the measured and predicted (QB_{RH}) values by following equation (10)

$$B_{FH} = \frac{|Q_{MH} - QB_{RH}|}{Q_{MH}} \times 100(\%) \qquad (10)$$

absolute relative differences for different loop lengths was calculated using equations (9) and (10). According to absolute relative difference values for grey fabric before sanforizing regression equation can predict with 72.2% accuracy.

For grey fabric after sanforizing; regression equation (11) was obtained from regression analysis absolute relative difference was calculated from the measured and predicted (QA_{RH}) values by following equation (12)

$$QA_{RH} = 2,4343L_A - 26,4 \qquad R^2=0,9335 \qquad (11)$$

$$B_{FH} = \frac{|Q_{MH} - QA_{RH}|}{Q_{MH}} \times 100(\%) \qquad (12)$$

absolute relative differences for different loop lengths was calculated using equations (11) and (12). According to absolute relative difference values for grey fabric after sanforizing regression equation can predict with 55.1% accuracy.

As seen from Figure 2 and 3, dyed fabric samples exhibited similar results with grey samples with respect to the effect of loop length and fabric weight and sanforazing process.

For dyed fabric before sanforizing; regression equation (13) was obtained from regression analysis absolute relative difference was calculated from the measured and predicted (QB_{RM}) values by following equation (14)

$$QB_{RM} = 0,7477L_A - 5,602 \qquad R^2 = 0,917 \qquad (13)$$

$$B_{FM} = \frac{|Q_{MM} - QB_{RM}|}{Q_{MM}} \times 100(\%) \qquad (14)$$

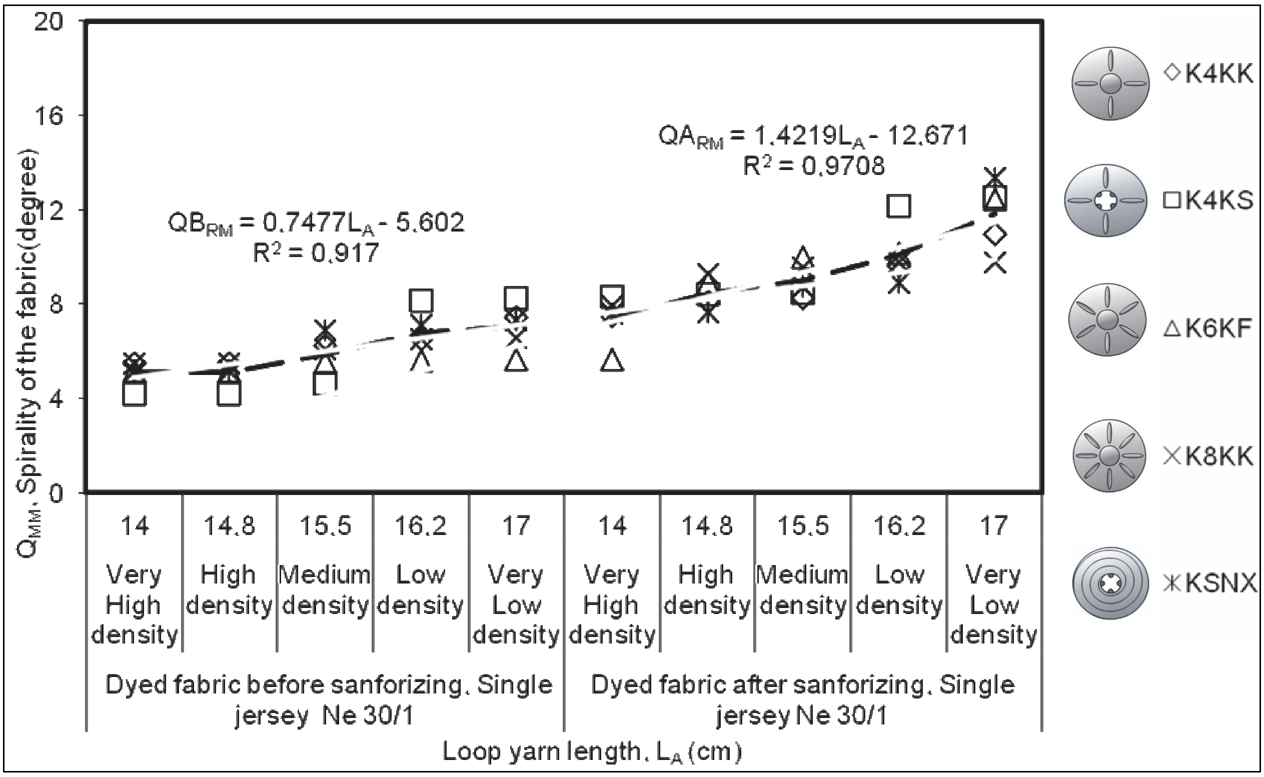

Figure 3. Spirality of dyed fabric before and after sanforizing

absolute relative differences for different loop lengths were calculated using equations (13) and (14). According to absolute relative difference values for dyed fabric before sanforizing regression equation can predict with 69.5% accuracy.

For dyed fabric after sanforizing; regression equation (15) was obtained from regression analysis absolute relative difference was calculated from the measured and predicted (QA_{RM}) values by following equation (16)

$$QA_{RM} = 1{,}4219L_A - 12{,}671 \qquad R^2=0{,}9708 \qquad (15)$$

$$B_{FM} = \frac{\left|Q_{MM} - QA_{RM}\right|}{Q_{MM}} \times 100(\%) \qquad (16)$$

absolute relative differences for different loop lengths were calculated using equations (15) and (16). According to absolute relative difference values for dyed fabric after sanforizing regression equation can predict with 71.6% accuracy.

4. STATISTICAL SIGNIFICANCE ANALYSIS

The experimental results have been statistically evaluated by Design Expert software with F values of the significance level of α=0.05. We evaluated the results based on the F-ratio and the probability of the F-ratio (prob>F). The lower the probability of the F-ratio, it is stronger the contribution of the variation and more significant the variable.

Table 8. summarizes the statistical significance analysis for all data obtained. In the table, variables are the NT – nozzle type, L_A - yarn loop length (cm), $NTxL_A$ the interactions of these two parameters. Moreover, C% is the contribution in per cent.

Statistically, nozzle type had no effect on dimensional stability and spirality. The yarn loop length as major factor has a great influence on the dimensional stability with the approximated contribution of between 70%-85%. The spirality is a major factor with the approximated contribution of between 29%-67%. Fabric characteristics of the bilateral interactions of the factors did not have a significant effect.

5. CONCLUSIONS

The followings give the outlines based on the experimental concept and data of this study as explained in detail in the main body of the paper.

- For grey and dyed single jersey knitted fabrics, loop length (L_A), had significant effect on course density (C_M), fabric weight (G_M), measured dimensional change for widthwise direction and lengthwise direction. However, nozzle type (NT) was not found to have a effect of on these properties.
- Loop length (L_A) can be addressed as one of the decisive and fundamental parameters of the machine on fabric weight.
- The effect of the loop length and nozzle type on grey and dyed fabric spirality before and after sanforizing was found to be significant according to the measurement results and statistical work.
- Looking at the overall trend of the curves, increase of loop yarn length (L_A) resulted in decrease of (C_A) course density in other words, decrease of fabric weight and increase of spirality.
- Additionally sanforizing process is effective on spirality in terms of grey and dyed fabrics. The effect of sanforizing process was more pronounced for grey fabric spirality.

ACKNOWLEDGEMENTS

Researchers thanks to Rieter company and Erbel agency for providing nozzles used in the study and and Fıstık Tekstil San. ve Tic. A.Ş. in Turkey for fabric production. This study was supported by MMF 2008.D3 Çukurova University Scientific Research Projects Unit within the scope of this PhD thesis.

Table 8. Statistical significance analysis of the data for the fabrics

Fabric properties	Nozzle type (NT)			The machine adjusted loop length (L_A)			Bilateral interaction $NTxL_A$	Undetermined effect (%)
	F-V Value	**P-V Value**	**C (%)**	**F-V Value**	**P-V Value**	**C (%)**	**C (%)**	
DSW_H	9.72	0.0002	7.43	112.21	<0.0001	85.77	3.37	3.44
DSL_H	33.27	<0.0001	14.76	169.23	<0.0001	75.10	7.48	2.66
DSW_M	2.30	0.0913	4.50	36.14	<0.0001	70.76	13.98	10.77
DSL_M	3.44	0.0294	5.47	51.40	<0.0001	81.66	5.71	7.15
QB_{MH}	12.89	<0.0001	10.50	82.95	<0.0001	67.62	16.78	5.09
QA_{MH}	18.05	<0.0001	10.02	123.66	<0.0001	68.68	17.82	3.47
QB_{MM}	3.64	0.0243	16.24	9.29	0.0003	41.45	22.22	20.09
QA_{MM}	3.87	0.0205	19.57	5.69	0.0043	28.71	30.26	21.46

Abbreviations in Table 8: grey and dyed fabric dimensional changes measured (DSL_M), measured of grey fabric (DSW_H, DSL_H), measured of dyed fabric (DSW_M, DSL_M), grey fabric sanforazing before and after spirality QB_{MH}, QA_{MH} dyed fabric sanforazing before and after spirality QB_{MM}, QA_{MM}.

REFERENCES

1. Quaynor L., Takahashi M. ve Nakajima M., 2000, “Effects of Laundering on the Surface Properties and Dimensional Stability of Plain Knitted Fabrics”, *Textile Research Journal*, 70(1), pp28-35.
2. Çoruh E., 2011, “Investigation of properties of single jersey fabrics made from OE-rotor yarns produced by using different nozzle types”, Ph.D. thesis Çukurova University Institute of Natural and Applied Sciences Department of Textile Engineering Adana. PhD thesis,. pp237.
3. Sharma, I. C., Ghosh S. and Gupta., 1985,“Dimensional and Physical Characteristcs of Single Jersey Fabrics” *Textile Research Institute*, March, pp149-156.
4. Tao. J., Dhingra. R.C., Chan. C.K., Abbas. M.S., 1997 “Effects of yarn and fabric construction on spirality of cotton single Jersey fabrics”, *Textile Research Journal,* pp57-68.
5. Araujo, M. D.,Smith G.W., 1989 **“**Spirality of Knitted Fabrics: Part I: The Nature of Spirality”, *Textile Research Journal*, vol:59, no:5, pp 247-256.
6. Quaynor L., Takahashi M. ve Nakajima M., 1998 “Effect of Laundering on Bending Properties of Plain-Knitted Fabrics”, *J. Text Mach. Soc. Japan (English Ed.)*, 4, pp 44.
7. Quaynor L., Masaru N., and Masaoki T., 1999, “Dimensional Changes in Knitted Silk and Cotton Fabrics with Laundering”, *Textile Research Journal*, 69(4), 285-291.
8. Anand S. C., Brown K. S. M., Higgins, L. G.,. 2002 “Effect of Laundering on the Dimensional Stability and Distortion of Knitted Fabrics”, *Autex Research Journal,* 2,2, pp85-100.
9. Çeken F. ve Kurbak A., 1999,“ Dimensional Properties of Knitted Fabrics Containing Different Materials” *Tekstil ve Mühendis*, 49-50, pp15-20.
10. Bayazıt Y., A.,1996 ”Investigation of Dimensional Stability of 1x1 Rib Knit Fabrics Produced from OE-Rotor Spun Yarn”, *Tekstil ve Konfeksiyon*, 1, pp35-41.
11. Önal L. ve Candan C.,2003”Contribution of Fabric Characteristics and Laundering to Shrinkage of Weft Knitted Fabrics”, *Textile Research Journal,* ,73(3),pp187-191.
12. Çelik N., Çoruh E., 2008,“Investigation of Performance and Structural Properties of Single Jersey Fabrics Made From Open-end Rotor Spun Yarns”, *Tekstil ve Konfeksiyon*, 4, pp268-277.
13. Souza A. A. U., Cherem L. F. C., Selene M. A., ve Souza G. U. 2010, “Prediction of Dimensional Changes in Circular Knitted Cotton Fabrics”, *Textile Research Journal*, , 80(3), pp236-252.
14. USTER HVI 900 Kataloğu, Textile Laboratory-Fiber Testing, 1991.
15. TS EN ISO 139,“Textiles-Standard atmospheres for conditioning and testing” 2008.
16. http://www.uster.com/UI/Statistics.aspx, 2010.
17. Çoruh E., Çelik N., 2013 “Influence of Nozzle Type on Yarn Quality in Open-End Rotor Spinning”, *Fibres&Textiles in Eastern Europe,* 21, 2(98): pp38-42.
18. TS EN 14970 “Textiles - Knitted fabrics - Determination of stitch length and yarn linear density in weft knitted fabrics”,2006.
19. TS EN 14971 “Textiles - Knitted fabrics - Determination of number of stitches per unit length and unit area”2006.
20. TS EN ISO 12127 “Textiles- Fabrics- Determination of mass per unit area using small samples”1999.
21. TS 5720 EN ISO 6330, “Textiles- Domestic washing and drying procedures for textile testing” 2002.
22. TS EN ISO 5077, “Textiles - Determination of dimensional change in washing and drying” 2009.
23. IWS TM 276 Woolmark Test Method “Test Method for the Angle of Spirality (in Plain Knitted Garments)” Mayıs, 2000.